

FORM-PTO-1390  
(Rev. 10-96)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER

024444-580

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)

09/214923

INTERNATIONAL APPLICATION NO.  
PCT/SE97/01243INTERNATIONAL FILING DATE  
July 8, 1997PRIORITY DATE CLAIMED  
July 19, 1996TITLE OF INVENTION  
CEMENTED CARBIDE INSERT FOR TURNING, MILLING AND DRILLINGAPPLICANT(S) FOR DO/EO/US  
Mats WALDENSTRÖM, Åke ÖSTLUND and Ove ALM

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1.  This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2.  This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3.  This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and the PCT Articles 22 and 39(1).
4.  A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5.  A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a.  is transmitted herewith (required only if not transmitted by the International Bureau).
  - b.  has been transmitted by the International Bureau.
  - c.  is not required, as the application was filed in the United States Receiving Office (RO/US)
6.  A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7.  Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a.  are transmitted herewith (required only if not transmitted by the International Bureau).
  - b.  have been transmitted by the International Bureau.
  - c.  have not been made; however, the time limit for making such amendments has NOT expired.
  - d.  have not been made and will not be made.
8.  A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9.  An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10.  A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11. to 16. below concern other document(s) or information included:

11.  An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12.  An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13.  A **FIRST** preliminary amendment.  
 A **SECOND** or **SUBSEQUENT** preliminary amendment.
14.  A substitute specification.
15.  A change of power of attorney and/or address letter.
16.  Other items or information:  
International Search Report; Preliminary Examination Report; and PCT Demand

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<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Claims</th> <th style="width: 25%;">Number Filed</th> <th style="width: 25%;">Number Extra</th> <th style="width: 25%;">Rate</th> </tr> </thead> <tbody> <tr> <td>Total Claims</td> <td>2 -20 =</td> <td>0</td> <td>X\$18.00</td> </tr> <tr> <td>Independent Claims</td> <td>1 -3 =</td> <td>0</td> <td>X\$78.00</td> </tr> <tr> <td colspan="3">Multiple dependent claim(s) (if applicable)</td> <td>+\$260.00</td> </tr> </tbody> </table>		Claims	Number Filed	Number Extra	Rate	Total Claims	2 -20 =	0	X\$18.00	Independent Claims	1 -3 =	0	X\$78.00	Multiple dependent claim(s) (if applicable)			+\$260.00		
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SEND ALL CORRESPONDENCE TO:  Ronald L. Grudziecki BURNS, DOANE, SWECKER & MATHIS, L.L.P. P.O. Box 1404 Alexandria, Virginia 22313-1404																			
 SIGNATURE Ronald L. Grudziecki NAME 24,970 REGISTRATION NUMBER																			

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INTERNATIONAL APPLICATION NO. PCT/SE97/01243		INTERNATIONAL FILING DATE July 8, 1997	U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 09/214,923
TITLE OF INVENTION CEMENTED CARBIDE INSERT FOR TURNING, MILLING AND DRILLING		PRIORITY DATE CLAIMED July 19, 1996	
*APPLICANT(S) FOR DO/EO/US Mats WALDENSTRÖM, Åke ÖSTLUND and Ove ALM			
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04/22/1999 PWD/DE 00000159 09214923

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 SIGNATURE				
Ronald L. Grudziecki NAME				
24,970 REGISTRATION NUMBER				

09/214924

300 Rec'd PCT/ITA 15 JAN 1999

Patent  
Attorney's Docket No. 024444-580

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

## **PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

## IN THE SPECIFICATION

Page 1, after the title and before the first paragraph, please add the heading

## --BACKGROUND OF THE INVENTION--:

line 20, after "time", please insert --,--;

line 22, after "milling", please insert --,--; and

line 32, after “in”, please insert --,--; and after “e.g.”, please insert --,--.

Page 2, line 4, after "drilling", please insert --,--;

line 14, after “cast)”, please insert `--,--;` and

line 17, after "steels", please insert --,--.

Page 3, line 4, before the paragraph beginning with "It has now surprisingly... ",  
please add the following heading and paragraph:

**--OBJECTS AND SUMMARY OF THE INVENTION**

It is an aspect of this invention to provide a method of making a cemented carbide insert provided with a thin wear resistant coating with excellent properties for machining of steels and stainless steels comprising WC, 5-12.5 wt-% Co and 0-10 wt-% cubic carbides such as TiC, TaC, NbC or mixtures thereof wherein the WC-grains have an average grain size in the range of 1.0-3.0  $\mu\text{m}$ , the WC grains have a narrow grain size distribution in the range 0.5-4.5  $\mu\text{m}$ , the W-content in the binder phase expressed as the "CW-ratio" defined as CW-ratio =  $M_s/\text{wt\% Co} \times 0.0161$  where  $M_s$  is the measured saturation magnetization of the sintered cemented carbide insert in kA/m and wt% Co is the weight percentage of Co in the cemented carbide, is 0.86-0.96.--;

after line 11, before the paragraph beginning with "Fig. 1 shows in... ",  
please add the following heading

**--BRIEF DESCRIPTION OF THE DRAWINGS--**

after line 15, before the paragraph beginning with "According to the invention... ", please add the following heading

**--DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION--**

line 16, after "invention", please insert --,--; and  
line 30, after "embodiment", please insert --,--.

Page 4, line 21, after "embodiment", please insert --,--;

line 24, after "invention", please insert --,--; and

line 35, after "milling", please insert --,--; and after "i.e.", please insert

--,--.

Page 5, line 11, after "embodiment", please insert --,--;

line 15, after "case", please insert --,--; and

after the paragraph ending at line 22, please insert the following new

paragraph:

--The invention is additionally illustrated in connection with the following Examples which are to be considered as illustrative of the present invention. It should be understood, however, that the invention is not limited to the specific details of the Examples.--.

Page 6, line 9, after "coating", please insert --,--.

Page 15, after the last paragraph ending at line 10, please insert the following new paragraph:

--The principles, preferred embodiments and modes of operation of the present invention have been described in the foregoing specification. The invention which is intended to be protected herein, however, is not to be construed as limited to the particular forms disclosed, since these are to be regarded as illustrative rather than restrictive. Variations and changes may be made by those skilled in the art without departing from the spirit of the invention.--.

Page 16, please delete "Claims" and insert therefor --WHAT IS CLAIMED IS--.

IN THE CLAIMS

Please amend claims 1 and 2 as follows:

1. (Amended) A cemented carbide insert provided with a thin wear resistant coating with excellent properties for machining of steels and stainless steels comprising [consisting of] WC, 5-12.5 wt-% Co and 0-10 wt-% cubic carbides such as TiC, TaC, NbC or mixtures thereof wherein [in which] the WC-grains have an average grain size in the range 1.0-3.0  $\mu\text{m}$ , [characterised in that] the WC grains have a narrow grain size distribution in the range 0.5-4.5  $\mu\text{m}$ , [and] the W-content in the binder phase expressed as the "CW-ratio" defined as

$$\text{CW-ratio} = M_s / \text{wt\% Co} * 0.0161$$

where  $M_s$  is the measured saturation magnetization of the sintered cemented carbide insert in kA/m and wt% Co is the weight percentage of Co in the cemented carbide, is 0.86-0.96.

2. (Amended) The [A] cemented carbide insert of [according to the preceding] claim 1 wherein [characterised in that] said coating comprises  $\text{TiC}_x\text{N}_y\text{O}_z$  with columnar grains followed by a layer of  $\alpha\text{-Al}_2\text{O}_3$ ,  $\kappa\text{-Al}_2\text{O}_3$  or a mixture of  $\alpha$ - and  $\kappa\text{-Al}_2\text{O}_3$ .

Page 17, line 1, please delete "Abstract" and insert therefor --ABSTRACT OF THE DISCLOSURE--;

line 2, please delete "The present invention relates to" and insert therefor  
--There is disclosed--; and

line 12, please delete "i".

REMARKS

The amendments to the above-identified application are clerical in nature and have been made to place the application in the accepted U.S. format. The new claims have been added to more clearly reflect Applicant's invention and an Abstract of the Disclosure has been included. No new matter has been added.

Early examination and allowance of the claims is earnestly solicited.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

Post Office Box 1404  
Alexandria, Virginia 22313-1404  
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By: Ronald L. Gryziecki  
Ronald L. Gryziecki  
Registration No. 24,970

Date: January 15, 1999

S00R00dP00746 15 JAN 1999

Cemented carbide insert for turning, milling and  
drilling

The present invention relates to a cemented carbide  
5 cutting tool insert, particularly useful for turning,  
milling and drilling of steels and stainless steels.

Conventional cemented carbide inserts are produced  
by powder metallurgical methods including milling of a  
powder mixture forming the hard constituents and the  
10 binder phase, pressing and sintering. The milling opera-  
tion is an intensive milling in mills of different  
sizes and with the aid of milling bodies. The milling  
time is of the order of several hours up to several  
days. Such processing is believed to be necessary in  
15 order to obtain a uniform distribution of the binder  
phase in the milled mixture. It is further believed that  
the intensive milling creates a reactivity of the  
mixture which further promotes the formation of a dense  
structure. However, milling has its disadvantages.  
20 During the long milling time the milling bodies are worn  
and contaminate the milled mixture. Furthermore even  
after an extended milling a random rather than an ideal  
homogeneous mixture may be obtained. Thus, the proper-  
ties of the sintered cemented carbide containing two or  
25 more components depend on how the starting materials are  
mixed.

There exist alternative technologies to intensive  
milling for production of cemented carbide, for example,  
use of particles coated with binder phase metal. The  
30 coating methods include fluidized bed methods, solgel  
techniques, electrolytic coating, PVD coating or other  
methods such as disclosed in e. g. GB 346,473, US  
5,529,804 or US 5,505,902. Coated carbide particles  
could be mixed with additional amounts of cobalt and  
35 other carbide powders to obtain the desired final

material composition, pressed and sintered to a dense structure.

During metal cutting operations like turning, milling and drilling the general properties such as hardness, resistance against plastic deformation, resistance against formation of thermal fatigue cracks are to a great extent related to the volume fraction of the hard phases and the binder phase in the sintered cemented carbide body. It is well known that increasing the amount of the binder phase reduces the resistance to plastic deformation. Different cutting conditions require different properties of the cutting insert. When cutting of steels with raw surface zones (e.g. rolled, forged or cast) a coated cemented carbide insert must consist of tough cemented carbide and have a very good coating adhesion as well. When turning, milling or drilling in low alloyed steels or stainless steels the adhesive wear is generally the dominating wear type.

Measures can be taken to improve the cutting performance with respect to a specific wear type. However, very often such action will have an negative effect on other wear properties.

The influence of some possible measures is given below:

1. Milling, turning or drilling at high cutting speeds and high cutting edge temperature require a cemented carbide with a rather large amount of cubic carbides (a solid solution of WC-TiC-TaC-NbC). Thermal fatigue cracks will often more easily develop in such carbides.

2. The formation of thermal fatigue cracks can be reduced by lowering the binder phase content. However, such action will lower the toughness properties of the cutting insert which is not desirable.

3. Improved abrasive wear can be obtained by increasing the coating thickness. However, thick coatings increase the risk for flaking and will lower the resistance to adhesive wear.

5 It has now surprisingly been found that cemented carbide inserts made from powder mixtures with hard constituents with narrow grain size distributions and without conventional milling have excellent cutting performance in steels and stainless steels with or  
10 without raw surfaces in turning, milling and drilling under both dry and wet conditions.

Fig. 1 shows in 1200X the microstructure of a cemented carbide insert according to the invention.

15 Fig. 2 shows in 1200X the microstructure of a corresponding insert made according to prior art.

According to the invention there is now provided cemented carbide inserts with excellent properties for machining of steels and stainless steels comprising WC and 4 - 20 wt-% Co, preferably 5 - 12.5 wt-% Co and 0 -  
20 30 wt-% cubic carbide, preferably 0 - 15 wt-% cubic carbide, most preferably 0 - 10 wt-% cubic carbide such as TiC, TaC, NbC or mixtures thereof. The WC-grains have an average grain size in the range 0.8 - 3.5  $\mu\text{m}$ , preferably 1.0 - 3.0  $\mu\text{m}$ . The microstructure of the cemented carbide according to the invention is further characterized by a narrow grain size distribution of WC in the range 0.5 - 4.5  $\mu\text{m}$ , and a lower tendency for the cubic carbide particles, when present, to form long range skeleton, compared to conventional cemented carbide.

30 In another alternative embodiment there is provided cemented carbide inserts comprising WC and 10 - 25 wt-% Co, preferably 15 - 20 wt-% Co, and <2 wt-%, preferably <1 wt-% cubic carbides such as  $\text{Cr}_3\text{C}_2$  and/or VC added as grain growth inhibitors. The WC-grains have an average grain size 0.2 - 1.0  $\mu\text{m}$ . The microstructure of cemented

carbide according to the invention is further characterized by a narrow grain size distribution of WC in the range 0 - 1.5  $\mu\text{m}$ .

The amount of W dissolved in binder phase is

5 controlled by adjustment of the carbon content by small additions of carbon black or pure tungsten powder. The W-content in the binder phase can be expressed as the "CW-ratio" defined as

$$\text{CW-ratio} = M_S / (\text{wt\%Co} * 0.0161)$$

10 where  $M_S$  is the measured saturation magnetization of the sintered cemented carbide body in kA/m and wt% Co is the weight percentage of Co in the cemented carbide. The CW-ratio in inserts according to the invention shall be 0.82 - 1.0, preferably 0.86 - 0.96.

15 The sintered inserts according to the invention are used coated or uncoated, preferably coated with MTCVD, conventional CVD or PVD with or without  $\text{Al}_2\text{O}_3$ . In particular, multilayer coatings comprising  $\text{TiC}_x\text{N}_y\text{O}_z$  with columnar grains followed by a layer of  $\alpha\text{-Al}_2\text{O}_3$ ,  $\kappa\text{-Al}_2\text{O}_3$  20 or a mixture of  $\alpha$ - and  $\kappa\text{-Al}_2\text{O}_3$ , have shown good results. In another preferred embodiment the coating described above is completed with a TiN-layer which could be brushed or used without brushing.

According to the method of the present invention WC-  
25 powder with a narrow grain size distribution is wet mixed without milling with deagglomerated powder of other carbides generally TiC, TaC and/or NbC, binder metal and pressing agent, dried preferably by spray drying, pressed to inserts and sintered.

30 WC-powder with a narrow grain size distributions according to the invention with eliminated coarse grain tails  $>4.5 \mu\text{m}$  and with eliminated fine grain tails,  $<0.5 \mu\text{m}$ , are prepared by sieving such as in a jetmill-classifier. It is essential according to the invention 35 that the mixing takes place without milling i.e. there

should be no change in grain size or grain size distribution as a result of the mixing.

Hard constituents with narrow grain size distributions according to the alternative embodiment with 5 eliminated coarse grain tails  $>1.5 \mu\text{m}$  are prepared by sieving such as in a jetmill classifier. It is essential according to the invention that the mixing takes place without milling i.e. there should be no change in grain size or grain size distribution as a result of the 10 mixing.

In a preferred embodiment the hard constituents, at least those with narrow grain size distribution, are after careful deagglomeration coated with binder metal using methods disclosed in US 5,505,902 or US 5,529,804.

15 In such case the cemented carbide powder according to the invention consists preferably of Co-coated WC + Co-binder, with or without additions of the cubic carbides, TiC, TaC, NbC, (Ti,W)C, (Ta,Nb)C, (Ti,Ta,Nb)C, (W,Ta,Nb)C, (W,Ti,Ta,Nb)C or Cr<sub>3</sub>C<sub>2</sub> and/or VC coated or 20 uncoated, preferably uncoated, possibly with further additions of Co-powder in order to obtain the desired final composition.

#### Example 1

25 A. Cemented carbide tool inserts of the type SEMN 1204 AZ, an insert for milling, with the composition 9.1 wt% Co, 1.23 wt% TaC and 0.30 wt% NbC and rest WC with a grain size of  $1.6 \mu\text{m}$  were produced according to the invention. Cobalt coated WC, WC-2 wt% Co, prepared 30 according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C and TaC powders to obtain the desired material composition. The mixing was carried out in an ethanol and water 35 solution (0.25 l fluid per kg cemented carbide powder)

for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase highly alloyed with W corresponding to a CW-ratio of 0.89. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained, Fig. 1.

Before coating a negative chamfer with an angle of 10 20° was ground around the whole insert.

The inserts were coated with a 0.5 µm equiaxed TiCN-layer (with a high nitrogen content corresponding to an estimated C/N-ratio of 0.05) followed by a 4 µm thick TiCN-layer with columnar grains by using MTCVD-technique 15 (temperature 885-850 °C and CH<sub>3</sub>CN as the carbon and nitrogen source). In subsequent steps during the same coating cycle, a 1.0 µm thick layer of Al<sub>2</sub>O<sub>3</sub> was deposited using a temperature 970 °C and a concentration of H<sub>2</sub>S dopant of 0.4 % as disclosed in EP-A-523 021. A thin 20 (0.3 µm) layer of TiN was deposited on top according to known CVD-technique. XRD-measurement showed that the Al<sub>2</sub>O<sub>3</sub>-layer consisted of 100 %  $\kappa$ -phase.

The coated inserts were brushed by a nylon straw brush containing SiC grains. Examination of the brushed 25 inserts in a light microscope showed that the thin TiN-layer had been brushed away only along the cutting edge leaving there a smooth Al<sub>2</sub>O<sub>3</sub>-layer surface.

Coating thickness measurements on cross sectioned brushed samples showed no reduction of the coating along 30 the edge line except for the outer TiN-layer that was removed.

B. Cemented carbide tool inserts of the type SEMN 1204 AZ with the same chemical composition, average grain size of WC, CW-ratio, chamfering and CVD-coating 35 respectively but produced from powder manufactured with

conventional ball milling techniques, Fig. 2, were used as reference.

5 Inserts from A were compared to inserts from B in a wet milling test in a medium alloyed steel (HB=210) with hot rolled and rusty surfaces. Two parallel bars each of a thickness of 33 mm were centrally positioned relative to the cutter body (diameter 100 mm) and with an air gap of 10 mm between them.

The cutting data were:

10 Speed= 160 m/min

Feed= 0.20 mm/rev

Cutting depth= 2 mm, single tooth milling with coolant.

15 Evaluated life length of variant A according to the invention was 3600 mm and for the standard variant B only 2400 mm. Since the CW-ratio, the negative chamfer and the coatings were equal for variants A and B, the differences in cutting performance depend on the improved properties obtained by the invention.

20

Example 2

A. Cemented carbide tool inserts of the type SEMN 1204 AZ according to the invention identical to the test specimen (A) in Example 1.

25

B. Cemented carbide tool inserts of the type SEMN 1204 AZ identical to the reference specimen (B) in Example 1.

30

C. A strongly competitive cemented carbide grade of the type SEKN 1204 from an external leading carbide producer with the composition 7.5 wt-% Co, 0.4 wt-% TaC, 0.1 wt% NbC, 0.3 wt% TiC rest WC and a CW-ratio of 0.95. The insert was provided with a coating consisting of a 0.5  $\mu$ m equiaxed TiCN-layer, 2.1  $\mu$ m columnar TiCN-layer, 2.2  $\mu$ m  $\kappa$ -Al<sub>2</sub>O<sub>3</sub>-layer and a 0.3  $\mu$ m TiN-layer.

Inserts from A were compared against inserts from B and C in a dry milling test in a low alloyed steel (HB=300) with premachined surfaces. A bar with a thickness of 180 mm was centrally positioned relative to the 5 cutter body (diameter 250 mm)

The cutting data were:

Speed= 150 m/min,

Feed= 0.23 mm/rev

Cutting depth= 2 mm, single tooth milling dry 10 conditions.

Insert B broke after 6000 mm after comb crack formation and chipping and insert C broke after 4800 mm by a similar wear pattern. Finally, insert A according to the invention, broke after 8000 mm.

15

### Example 3

A. Cemented carbide tool inserts of the type CNMG 120408-QM, an insert for turning, with the composition 8.0 wt% Co, and rest WC with a grain size of 3.0  $\mu\text{m}$  were 20 produced according to the invention. Cobalt coated WC, WC-8 wt% Co, prepared according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide 25 powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase alloyed with W corresponding to a CW-ratio of 0.93. After spray drying, the 30 inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with conventional CVD TiN+TiCN, 1+1  $\mu\text{m}$ .

B. Cemented carbide tool inserts of the type CNMG 120408-QM with the same chemical composition, average grain size of WC, CW-ratio and the same CVD-coating respectively but produced from powder manufactured with 5 conventional ball milling techniques were used as reference.

Inserts from A and B were compared in a face turning test where the resistance against plastic deformation was measured as the flank wear. The work piece material 10 was a rather highly alloyed steel, a bar with diameter 180 mm (HB=310). The cutting data were:

Speed= 290 m/min

Feed= 0.30 mm/rev

Depth of cut= 2 mm

15 The flank wear after two passages (average for three edges per variant) was found to be 0.27 mm for variant A according to the invention and 0.30 for variant B.

#### Example 4

20 A. Cemented carbide inserts of the type CNMG120408-MM, an insert for turning, with the composition 10.5 wt-% Co, 1.16 wt-% Ta, 0.28 wt-% Nb and rest WC with a grain size of 1.6  $\mu$ m were produced according to the invention. Cobalt coated WC, WC-6 wt% Co, prepared 25 according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C and TaC powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution 30 (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with carbon black to a binder phase highly alloyed with W corresponding to a CW-ratio of 0.87. After spray drying, the 35

inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 0.5  $\mu\text{m}$  equiaxed TiCN-layer with a high nitrogen content, corresponding to an estimated C/N ratio of 0.05, followed by a 4.2  $\mu\text{m}$  thick layer of columnar TiCN deposited using MT-CVD technique. In subsequent steps during the same coating process a 1.0  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$  consisting of pure  $\kappa$ -phase according to procedure disclosed in EP-A-523 021. A thin, 0.5  $\mu\text{m}$ , TiN layer was deposited, during the same cycle, on top of the  $\text{Al}_2\text{O}_3$ -layer.

The coated insert was brushed by a SiC containing nylon straw brush after coating, removing the outer TiN layer on the edge.

B. Cemented carbide tool inserts of the type CNMG120408-MM with the same chemical composition, average grain size of WC, CW-ratio and the same CVD-coating respectively but produced from powder manufactured with conventional ball milling techniques were used as reference.

Inserts from A and B were compared in facing of a bar, diameter 180, with two, opposite, flat sides (thickness 120 mm) in 4LR60 material (a stainless steel).

The cutting data were:

Feed= 0.25 mm/rev,

Speed= 180 m/min and

Depth of cut= 2.0 mm.

The wear mechanism in this test was chipping of the edge.

## Result

Insert	Number of cuts
A, according to the invention	19
B	15

Example 5

A. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt-% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the invention. Cobalt coated WC, WC-5 wt-% Co, prepared according to US 5,505,902 was carefully deagglomerated in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt-% lubricant, was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

B. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt-% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the invention. Uncoated deagglomerated WC was mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain a desired

material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, 5 was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, the inserts were pressed and sintered according to standard practise and dense structures with no porosity 10 were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

C. Cemented carbide turning tool inserts of the type 15 CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt-% Ti and rest WC produced from powder manufactured with conventional ball milling techniques with the same CW-ratio and almost the same 20 average WC-grain size as insert A and B were coated with the same coating as insert A and B.

Inserts from A, B and C were compared in an external longitudinal turning test with cutting speed 220 m/min and 190 m/min resp., a depth of cut of 2 mm, and a feed per tooth equal to 0.7 mm/revolution. The work piece 25 material was SS 2541 with a hardness of 300 HB and a diameter of 160 mm. The wear criteria in this test was the measure of the edge depression in  $\mu\text{m}$ , which reflects the inverse resistance against plastic deformation. A lower value of the edge depression indicates higher 30 resistance against plastic deformation.

The following results were obtained:

	v= 190 m/min	v= 220 m/min
	edge depression, $\mu\text{m}$	edge depression, $\mu\text{m}$
	A 59	85
5	B 56	93
	C 89	116

Since the general toughness behaviour was similar it is clear that both insert A produced from Co-coated WC and insert B produced from uncoated WC both according to 10 the invention, performed better than insert C produced with conventional techniques.

#### Example 6

A. Cemented carbide turning tool inserts of the type 15 CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt-% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the invention. Cobalt coated WC, WC-5 wt% Co, prepared according to US 5,505,902 was carefully deagglomerated 20 in a laboratory jetmill equipment, mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, 25 the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same 30 coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

B. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC with a grain size of 1.6  $\mu\text{m}$  were produced according to the 5 invention. Uncoated deagglomerated WC was mixed with additional amounts of Co and deagglomerated uncoated (Ta,Nb)C, TaC and (Ti,W)C powders to obtain desired material composition. The mixing was carried out in an ethanol and water solution (0.25 l fluid per kg cemented 10 carbide powder) for 2 hours in a laboratory mixer and the batch size was 10 kg. Furthermore, 2 wt% lubricant, was added to the slurry. The carbon content was adjusted with tungsten powder to a binder phase alloyed with W corresponding to a CW-ratio of 0.95. After spray drying, 15 the inserts were pressed and sintered according to standard practise and dense structures with no porosity were obtained.

The inserts were coated with an innermost 5  $\mu\text{m}$  layer of TiCN, followed by in subsequent steps during the same 20 coating process a 6  $\mu\text{m}$  layer of  $\text{Al}_2\text{O}_3$ .

C. Cemented carbide turning tool inserts of the type CNMG120408-PM with the composition 5.48 wt-% Co, 3.30 wt-% Ta, 2.06 wt-% Nb, 2.04 wt% Ti and rest WC produced from powder manufactured with conventional ball milling 25 techniques with the same CW-ratio and almost the same average WC-grain size as insert A and B were coated with the same coating as insert A and B.

Inserts from A, B and C were compared in a external 30 longitudinal turning test with cutting data 240 m/min, a dept of cut of 2 mm, and a feed per tooth equal to 0.7 mm/revolution. The work piece material was SS 2541 with an hardness of 300 HB and a diameter of 160 mm. The wear criteria in this test was the measure of the maximum flank wear after 5 min in cutting time, which reflects 35 the resistance against plastic deformation.

The following results were obtained

max. flank wear,  $\mu\text{m}$

5	A	28
	B	35
	C	38

Since the general toughness behaviour was similar it is clear that both insert A produced from Co-coated WC, and insert B produced from uncoated WC both according to the invention, performed better than insert C produced with conventional techniques.

10 with conventional techniques.

Claims

1. A cemented carbide insert provided with a thin wear resistant coating with excellent properties for machining of steels and stainless steels consisting of WC, 5 - 12.5 wt-% Co and 0 - 10 wt-% cubic carbides such as TiC, TaC, NbC or mixtures thereof in which the WC-grains have an average grain size in the range 1.0 - 3.0 mm characterised in that the WC grains have a narrow grain size distribution in the range 0.5 - 4.5 mm and the W-content in the binder phase expressed as the "CW-ratio" defined as

$$\text{CW-ratio} = M_S / \text{wt\%Co} * 0.0161$$

where  $M_S$  is the measured saturation magnetization of the sintered cemented carbide insert in kA/m and wt% Co is the weight percentage of Co in the cemented carbide is 0.86 - 0.96.

2. A cemented carbide insert according to the preceding claim characterised in that said coating comprises  $\text{TiC}_x\text{N}_y\text{O}_z$  with columnar grains followed by a layer of a- $\text{Al}_2\text{O}_3$ , k- $\text{Al}_2\text{O}_3$  or a mixture of a- and k- $\text{Al}_2\text{O}_3$ .

Abstract

The present invention relates to a cemented carbide insert with excellent properties for machining of steels and stainless steels. The cemented carbide comprises WC and 4 - 25 wt-% Co. The WC-grains have an average grain size in the range 0.2 - 3.5  $\mu\text{m}$  and a narrow grain size distribution in the range 0 - 4.5  $\mu\text{m}$ .

According to the method of the invention a cemented carbide cutting tool insert is made by mixing powders of WC, TiC, TaC and/or NbC, binder metal and pressing agent, drying preferably by spray drying, pressing to inserts and sintering. The method is characterised in

- that a deagglomerated WC-powder with a narrow grain size distribution is used,
- that the powders of TiC, TaC and/or NbC are deagglomerated and
- that the mixing is wet mixing with no change in grain size or grain size distribution.

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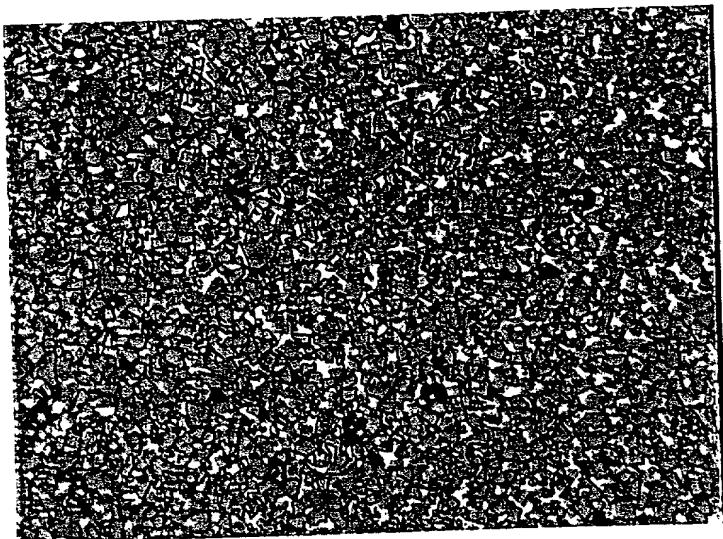


Fig. 1

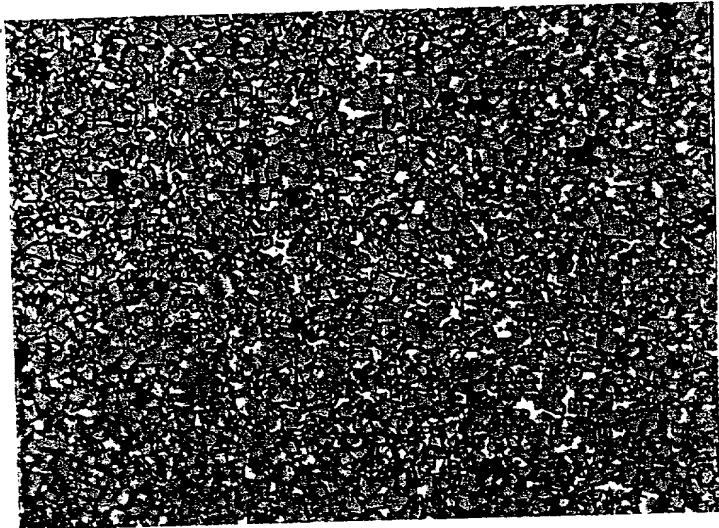


Fig. 2

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY  
(Includes Reference to Provisional and PCT International Applications)

ATTORNEY'S DOCKET NUMBER

024444-580

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

CEMENTED CARBIDE INSERT FOR TURNING, MILLING AND DRILLING

the specification of which (check only one item below):

is attached hereto.

was filed as United States application

Number \_\_\_\_\_

on January 15, 1999

and was amended

on \_\_\_\_\_ (if applicable).

was filed as PCT international application

Number \_\_\_\_\_

on \_\_\_\_\_

and was amended under PCT Article 19

on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(e) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

## PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119:

COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. §119
Sweden	9602811-3	19 July 1996	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
PCT	PCT/SE97/01243	8 July 1997	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

(Application Number)

(Filing Date)

(Application Number)

(Filing Date)

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONTINUED) (Includes Reference to Provisional and PCT International Applications)		ATTORNEY'S DOCKET NO. 024444-580																																																																																													
<p>I hereby claim the benefit under Title 35, United States Code, §120 of any United States applications(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose to the Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations §1.56, which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application:</p>																																																																																															
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<p>I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%; text-align: right; padding-right: 10px;">34</td> <td style="width: 25%; text-align: right; padding-right: 10px;">William L. Mathis</td> <td style="width: 25%; text-align: right; padding-right: 10px;">17,337</td> <td style="width: 25%; text-align: right; padding-right: 10px;">George A. Hovanec, Jr.</td> <td style="width: 25%; text-align: right; padding-right: 10px;">28,223</td> <td style="width: 25%; text-align: right; padding-right: 10px;">Peter K. Skiff</td> <td style="width: 25%; text-align: right; padding-right: 10px;">31,917</td> </tr> <tr> <td></td> <td style="text-align: right;">Peter H. Smolka</td> <td style="text-align: right;">15,913</td> <td style="text-align: right;">James A. LaBarre</td> <td style="text-align: right;">28,632</td> <td style="text-align: right;">Richard J. McGrath</td> <td style="text-align: right;">29,195</td> </tr> <tr> <td></td> <td style="text-align: right;">Robert S. Swecker</td> <td style="text-align: right;">19,885</td> <td style="text-align: right;">E. Joseph Gess</td> <td style="text-align: right;">28,510</td> <td style="text-align: right;">Matthew L. Schneider</td> <td style="text-align: right;">32,814</td> </tr> <tr> <td></td> <td style="text-align: right;">Platon N. Mandros</td> <td style="text-align: right;">22,124</td> <td style="text-align: right;">R. Danny Huntington</td> <td style="text-align: right;">27,903</td> <td style="text-align: right;">Michael G. Savage</td> <td style="text-align: right;">32,596</td> </tr> <tr> <td></td> <td style="text-align: right;">Benton S. Duffett, Jr.</td> <td style="text-align: right;">22,030</td> <td style="text-align: right;">Eric H. Weisblatt</td> <td style="text-align: right;">30,505</td> <td style="text-align: right;">Gerald F. Swiss</td> <td style="text-align: right;">30,113</td> </tr> <tr> <td></td> <td style="text-align: right;">Norman H. Stepno</td> <td style="text-align: right;">22,716</td> <td style="text-align: right;">James W. Peterson</td> <td style="text-align: right;">26,057</td> <td style="text-align: right;">Michael J. Ure</td> <td style="text-align: right;">33,089</td> </tr> <tr> <td></td> <td style="text-align: right;">Ronald L. Grudziecki</td> <td style="text-align: right;">24,970</td> <td style="text-align: right;">Teresa Stanek Rea</td> <td style="text-align: right;">30,427</td> <td style="text-align: right;">Charles F. Wieland III</td> <td style="text-align: right;">33,096</td> </tr> <tr> <td></td> <td style="text-align: right;">Frederick G. 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Miller, III</td> <td style="text-align: right;">27,360</td> <td style="text-align: right;">Patrick C. Keane</td> <td style="text-align: right;">32,858</td> <td style="text-align: right;">Harold R. Brown III</td> <td style="text-align: right;">36,341</td> </tr> <tr> <td></td> <td style="text-align: right;">Ralph L. Freeland, Jr.</td> <td style="text-align: right;">16,110</td> <td style="text-align: right;">Bruce J. Boggs, Jr.</td> <td style="text-align: right;">32,344</td> <td style="text-align: right;">Allen R. Baum</td> <td style="text-align: right;">36,086</td> </tr> <tr> <td></td> <td style="text-align: right;">Robert G. Mukai</td> <td style="text-align: right;">28,531</td> <td style="text-align: right;">William H. Benz</td> <td style="text-align: right;">25,952</td> <td style="text-align: right;">Steven M. du Bois</td> <td style="text-align: right;">35,023</td> </tr> </table>					34	William L. Mathis	17,337	George A. Hovanec, Jr.	28,223	Peter K. Skiff	31,917		Peter H. Smolka	15,913	James A. LaBarre	28,632	Richard J. McGrath	29,195		Robert S. Swecker	19,885	E. Joseph Gess	28,510	Matthew L. Schneider	32,814		Platon N. Mandros	22,124	R. Danny Huntington	27,903	Michael G. Savage	32,596		Benton S. Duffett, Jr.	22,030	Eric H. Weisblatt	30,505	Gerald F. Swiss	30,113		Norman H. Stepno	22,716	James W. Peterson	26,057	Michael J. Ure	33,089		Ronald L. Grudziecki	24,970	Teresa Stanek Rea	30,427	Charles F. Wieland III	33,096		Frederick G. Michaud, Jr.	26,003	Robert E. Krebs	25,885	Bruce T. Wieder	33,815		Alan E. Kopecki	25,813	William C. Rowland	30,888	Todd R. Walters	34,040		Regis E. Slutter	26,999	T. Gene Dillahunt	25,423	Ronni S. Jillions	31,979		Samuel C. Miller, III	27,360	Patrick C. Keane	32,858	Harold R. Brown III	36,341		Ralph L. Freeland, Jr.	16,110	Bruce J. Boggs, Jr.	32,344	Allen R. Baum	36,086		Robert G. Mukai	28,531	William H. Benz	25,952	Steven M. du Bois	35,023
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<p>and:</p> <p>Address all correspondence to: <u>Ronald L. Grudziecki</u>  <u>BURNS, DOANE, SWECKER &amp; MATHIS, L.L.P.</u>  <u>P.O. Box 1404</u>  <u>Alexandria, Virginia 22313-1404</u></p> <p>Address all telephone calls to: <u>Ronald L. Grudziecki</u> at (703) 836-6620.</p> <p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.</p>																																																																																															

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONTINUED)  
(Includes Reference to Provisional and PCT International Applications)

ATTORNEY'S DOCKET NO.

024444-580

FULL NAME OF SOLE OR FIRST INVENTOR <i>Mats WALDENSTRÖM</i>		SIGNATURE <i>Mats Waldenström</i>	DATE <i>Febr. 4 1999</i>
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FULL NAME OF FOURTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			
FULL NAME OF FIFTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			
FULL NAME OF SIXTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			
FULL NAME OF SEVENTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			
FULL NAME OF EIGHTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			
FULL NAME OF NINTH JOINT INVENTOR, IF ANY		SIGNATURE	DATE
RESIDENCE		CITIZENSHIP	
POST OFFICE ADDRESS			